Title : Latest SCR Technologies and Experience on Coal-Fired Boilers

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Summary

1. Introduction

A new 1,000MW capacity coal fired utility boiler which was designed, fabricated, constructed and commissioned by Mitsubishi has begun commercial operation in July 1997. The pulverized coal fired boiler together with all auxiliary equipment including the SCR system has been successfully operating since then.

Our presentation will introduce the latest SCR technologies and design features that were incorporated into this boiler including actual operating data from the SCR system.

Special characteristics and features of the SCR system design as well as the homogeneous honeycomb type SCR catalyst will be discussed with reference to catalyst plugging issues, erosion and optimizing the design of the ammonia injection system.

2. Features of the Latest 1,000MW Boiler and SCR System

The boiler is an indoor type, reheat, once through, balanced draft, pulverized coal fired boiler with 1,000MW capacity and supercritical sliding steam pressure operating conditions.

Based on numerous coal fired boiler construction and operating experience, the most economical combination of low NOx combustion systems and NOx removal systems have been selected. The Mitsubishi low NOx PM (Pollution Minimum) burners are used to minimize initial NOx formation in the furnace during the combustion stage. PM burners feature the dual flame slow combustion method. The new Mitsubishi advanced A-MACT (Multi AA) reburning system is used to reduce NOx in the furnace before exiting the boiler.

The SCR system for the new 1,000MW boiler is currently one of the largest single capacities in the world. The fixed bed vertical flue gas flow type arrangement used here has been the standard and most reliable system for these large capacity coal fired utility boiler applications. Grid ceramic homogeneous honeycomb type catalyst has been used for maximum NOx removal performance, high reliability and minimum possibility of ash plugging and erosion. Anhydrous ammonia is evaporated and diluted before being injected into the flue gas at the ammonia injection grid.

Flue gas from the boiler economizer outlet duct exits the boiler horizontally and makes a 90 degree bend upward to enter the top of the SCR reactor. A hopper is provided at the end of the horizontal duct to minimize dust accumulation and to collect larger ash particles. Economizer bypass ducts and control dampers are provided to bypass some of the flue gas entering the boiler economizer during low boiler loads in order to maintain the minimum flue gas temperature required for SCR operation. Flue gas turning vanes are installed at the inlet of the reactor housing to evenly distribute the flue gas flow across the catalyst inlet face.

3. Performance Results from 1,000MW SCR System

NOx values at the economizer outlet ducts were measured to confirm the inlet conditions of the SCR system. NOx distribution at the outlet of each of the reactor housings were also measured and used as an indicator to adjust the manual ammonia injection control valves at the AIG manifolds. After one series of valve opening adjustments on both sides of the ducts were done, NOx distribution was measured again at the outlet of each of the reactor housings and were noted to be approximately plus-minus 10% of the average value at each duct. This was confirmed to be sufficient to meet the required SCR performance.

The overall performance of the SCR system at rated boiler capacity showed an inlet NOx of 0.26 lb/MMbtu (144ppm@6%O2) at the economizer outlet and an outlet NOx of 0.05 lb/MMbtu (28ppm@6%O2) at the SCR reactor outlet which corresponds to a NOx reduction efficiency of 81%. Ammonia slip at this condition was less than 1 ppm@6%O2 at the SCR outlet.

Design conditions for the SCR system were 0.40 lb/MMbtu (225ppm@6%O2) NOx at the economizer outlet and 0.11 lb/MMbtu (60ppm@6%O2) NOx at the SCR reactor outlet which corresponds to a NOx reduction efficiency of 73%. The design ammonia slip was 3 ppm@6%O2. Therefore, all of the design conditions were fully met with sufficient margin for daily normal operations.

The SOx and SO3 at the economizer inlet were 413 ppm and 2.1 ppm respectively and the SO3 at the SCR outlet was 4.0 ppm which calculates to a SO2 to SO3 conversion rate of 0.5% at the SCR. This was considered sufficiently low to avoid any problems at the flue gas downstream equipment.

The flue gas pressure drop through the SCR system was measured to be 2.2 inwg at rated boiler capacity. This was over 1.0 inwg lower than the original design value of 3.5 inwg.

4. Characteristics and Features of the Homogeneous Honeycomb SCR Catalyst

The Ti-V-W based homogeneous grid honeycomb type catalyst has been selected to be used for this new SCR system. Some of the characteristics and features such as anti-plugging and anti-erosion were considered when selecting catalyst. The homogeneous honeycomb type catalyst has been used and tested extensively in Mitsubishi's SCR systems and are now considered part of the standard design. Over 70% of the utilities in Japan use the same or similar homogeneous honeycomb type catalyst for their utility boiler SCR systems.

5. System Design Considerations

In addition to proper catalyst design and selections, there are some system design considerations necessary for a successful overall design. The entire SCR system arrangement including the reactor housing, inlet and outlet flue gas ducting and the ammonia injection system are all reviewed during the design stage to have the best performance and economical design. For retrofit projects, this becomes more important since the new SCR portion will have to fit into the existing equipment which is often tightly arranged already.

Conclusion

The design conditions and actual operating data from the boiler and SCR system have been presented and it has been confirmed that the high NOx reduction requirements have been satisfied. Many special features on both the SCR catalyst design and system design have been incorporated into the design of this boiler and these technologies can be effectively applied to retrofit SCR projects.